

Problem Set #9

①

① (a) $K = \frac{[O_2]^3}{[O_3]^2}$ homogeneous

(b) $K = \frac{1}{[Cl_2]^2}$ heterogeneous

(c) $K = \frac{[C_2H_6][O_2]}{[C_2H_4]^2 [H_2O]^2}$ homogeneous

(d) $K = \frac{[Cl_2]^2}{[HCl]^4 [O_2]}$ heterogeneous

② $[CO] = \frac{0.170 \text{ mol}}{2.00 \text{ L}} = 0.0850 \text{ M}$ $[CH_3OH] = \frac{0.0406 \text{ mol}}{2.00 \text{ L}} = 0.0203 \text{ M}$

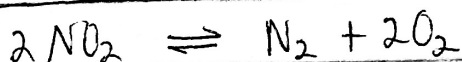
$[H_2] = \frac{0.302 \text{ mol}}{2.00 \text{ L}}$

$K = \frac{[CH_3OH]}{[CO][H_2]^2} = \frac{(0.0203)}{(0.0850)(0.151)^2} = 10.5$

$K > 1$ Forward Rx (product) favored.

③ $2NO \rightleftharpoons \frac{1}{2}N_2 + \frac{1}{2}O_2$ $K_1 = \left(\frac{1}{4.8 \times 10^{-10}} \right)^2$

$2NO_2 \rightleftharpoons 2NO + O_2$ $K_2 = 1.1 \times 10^{-5}$



$K_{\text{overall}} = K_1 \times K_2 = \left(\frac{1}{4.8 \times 10^{-10}} \right)^2 \times (1.1 \times 10^{-5}) = 4.8 \times 10^{13}$

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④ Initial concentrations of H_2 & Br_2

$$H_2: 1.374 \text{ g } H_2 \left(\frac{1 \text{ mol } H_2}{2.02 \text{ g } H_2} \right) = 0.680 \text{ mol } H_2$$

$$M = \frac{0.680 \text{ mol}}{2.50 \text{ L}} = 0.272 \text{ M}$$

$$Br_2: 70.31 \text{ g } Br_2 \left(\frac{1 \text{ mol } Br_2}{159.8 \text{ g } Br_2} \right) = 0.440 \text{ mol } Br_2$$

$$M = \frac{0.440 \text{ mol}}{2.50 \text{ L}} = 0.176 \text{ M}$$

Equilibrium concentration of H_2 :

$$0.566 \text{ g } H_2 \left(\frac{1 \text{ mol } H_2}{2.02 \text{ g } H_2} \right) = 0.280 \text{ mol } H_2$$

$$M = \frac{0.280 \text{ mol}}{2.50 \text{ L}} = 0.112 \text{ M}$$

	$[Br_2]$	$[H_2]$	$[HBr]$
Initial	0.176	0.272	0
Change	-0.160	-0.160	+0.320
Equil	0.016	0.112	0.320

⇐ Equilibrium concentrations

$$K = \frac{[HBr]^2}{[Br_2][H_2]} = \frac{(0.320)^2}{(0.016)(0.112)} = \underline{\underline{57}}$$

Equilibrium concentrations : $[Br_2] = 0.016 \text{ M}$ $[H_2] = 0.112 \text{ M}$ $[HBr] = 0.320 \text{ M}$

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$$⑤ \quad Q = \frac{[CO][Cl_2]}{[COCl_2]} = \frac{(3.3 \times 10^{-6})(6.62 \times 10^{-6})}{(2.00 \times 10^{-3})} = 1.1 \times 10^{-8}$$

$Q \gg K$ $\nearrow 2.19 \times 10^{-10}$ R runs left

⑥

$$K = \frac{[BrCl]^2}{[Br_2][Cl_2]} = 7.0$$

$$\frac{(2x)^2}{(0.25-x)(0.25-x)} = 7.0$$

	$[Br_2]$	$[Cl_2]$	$[BrCl]$
I	0.25	0.25	0
C	-x	-x	+2x
E	0.25-x	0.25-x	2x

$$\frac{2x}{0.25-x} = \sqrt{7.0}$$

$$[Br_2] = [Cl_2] = 0.25M - 0.14M = 0.11M$$

$$[BrCl] = 2(0.14M) = 0.28M$$

equilibrium concentrations

$$4.6x = 0.66$$

$$x = 0.14M$$

⑦

The following reaction is exothermic: $2 Cl_2 (g) + C (s) \leftrightarrow CCl_4 (g) + 9$

I. Predict the effect (shift right, shift left, or no effect) of the following:

- (a) Adding more CCl_4 to the reaction mixture: shifts left
- (b) Increasing the temperature of the reaction mixture: shifts left
- (c) Adding more C to the reaction mixture: no effect
- (d) Adding more Cl_2 to the reaction mixture: shifts right
- (e) Decreasing the volume of the reaction mixture: shifts right
- (f) Adding a catalyst to the reaction mixture: no effect

II. Will the equilibrium constant of the reaction increase or decrease if the temperature is increased?

K decreases